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[54] **TAMPER DETECTION DEVICE**

[75] Inventors: **Howard Christopher Rivenberg**; **Aaron William Levine**; **Nitin Vithalbhai Desai**, all of Mercer, N.J.

[73] Assignee: **David Sarnoff Research Center, Inc.**, Princeton, N.J.

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[51] **Int. Cl.**[6] **G08B 13/06**; G08B 13/10; G08B 13/22

[52] **U.S. Cl.** **340/550**; 340/540; 340/541; 340/562; 340/652

[58] **Field of Search** 340/550, 562, 340/541, 652, 540

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,506,566 4/1996 Oldfield et al. 340/550

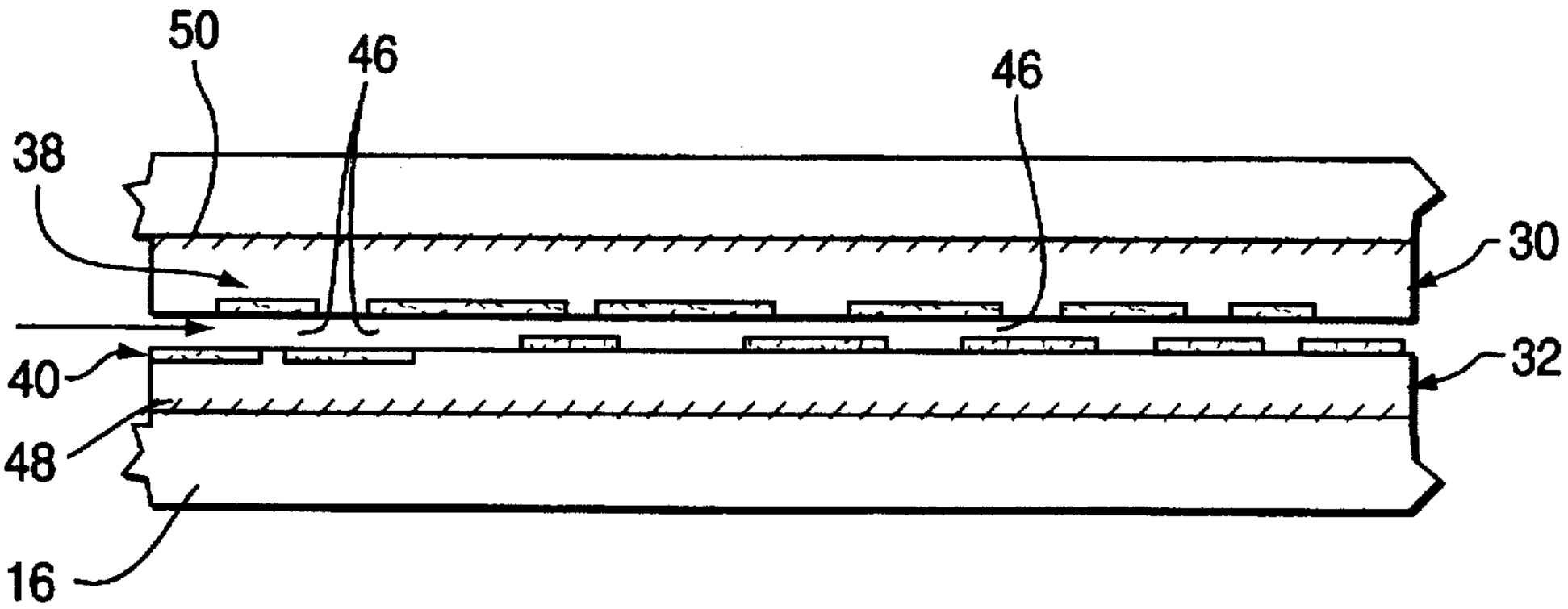
Primary Examiner—Glen Swann

Attorney, Agent, or Firm—William J. Burke

[57] **ABSTRACT**

A tamper detection device can determine whether a housing containing a device has been tampered with either by having the housing penetrated or by an attempt to remove a cover from the housing. The tamper detection device may be a capacitor which is placed across a portion of the housing and whose capacitance changes if it is penetrated. The temper detection device may also be a flexible circuit having conductive strips thereon forming a circuit with means to cause an open circuit if the housing is penetrated or the cover removed from the housing.

9 Claims, 4 Drawing Sheets



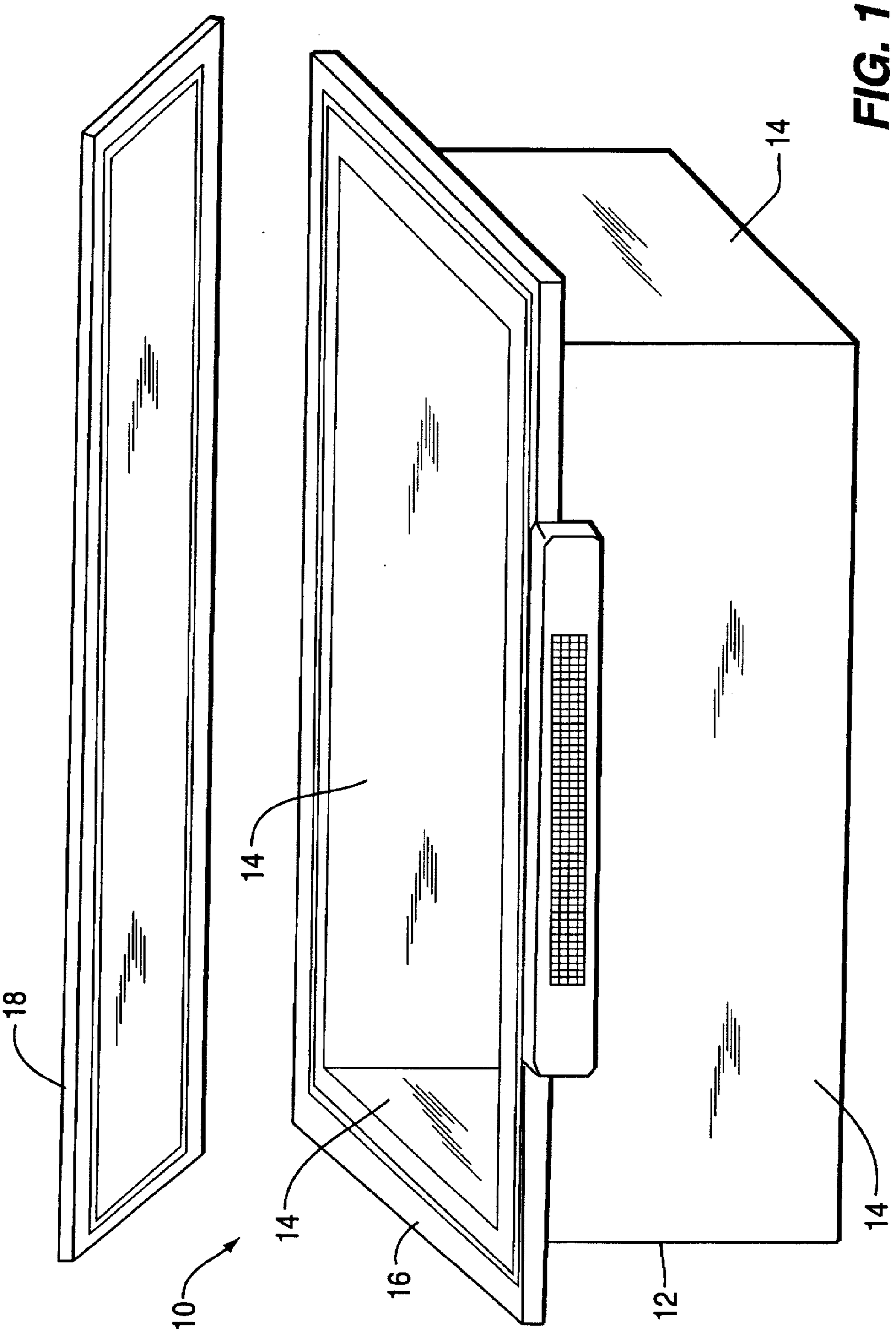


FIG. 1

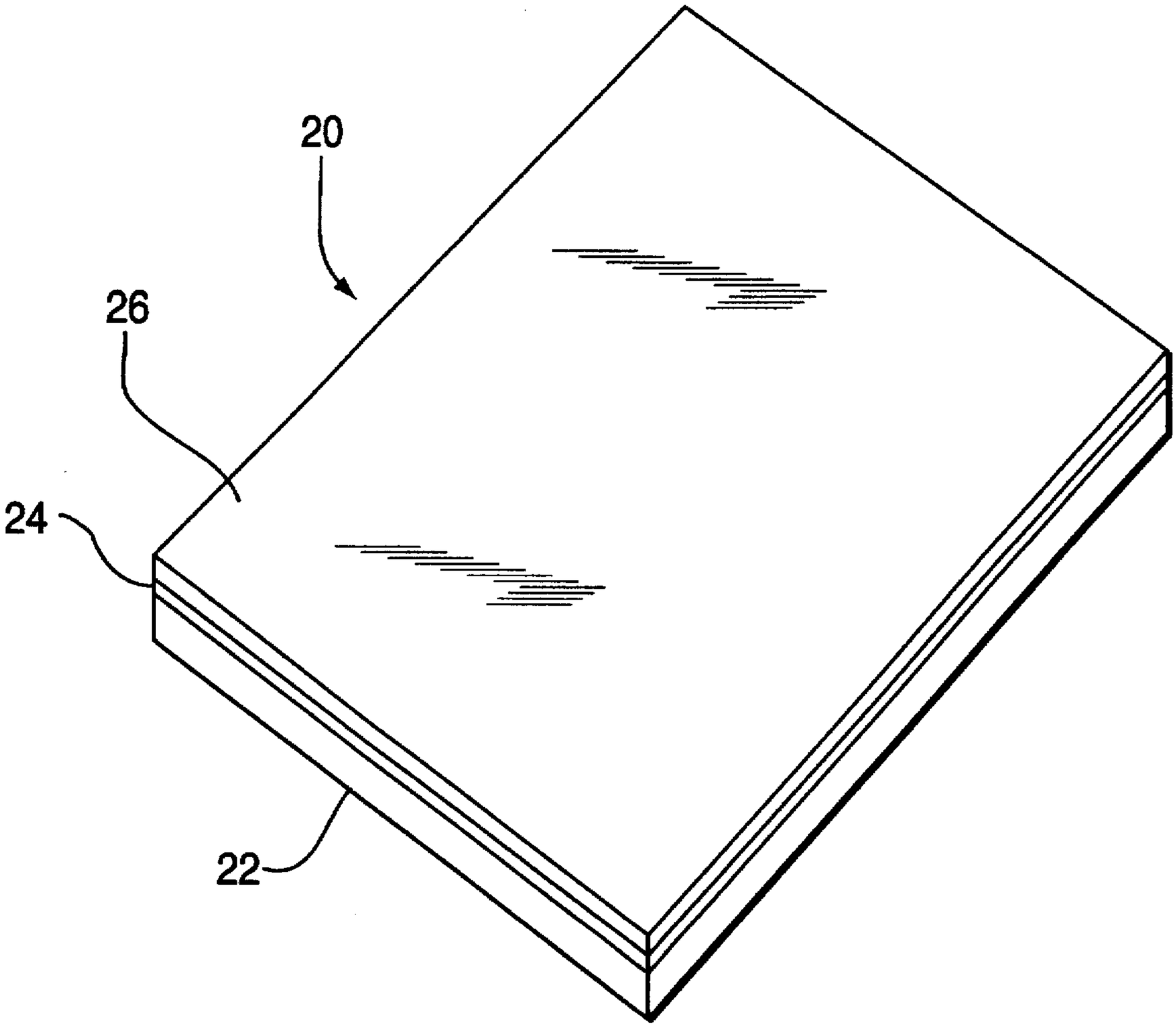


FIG. 2

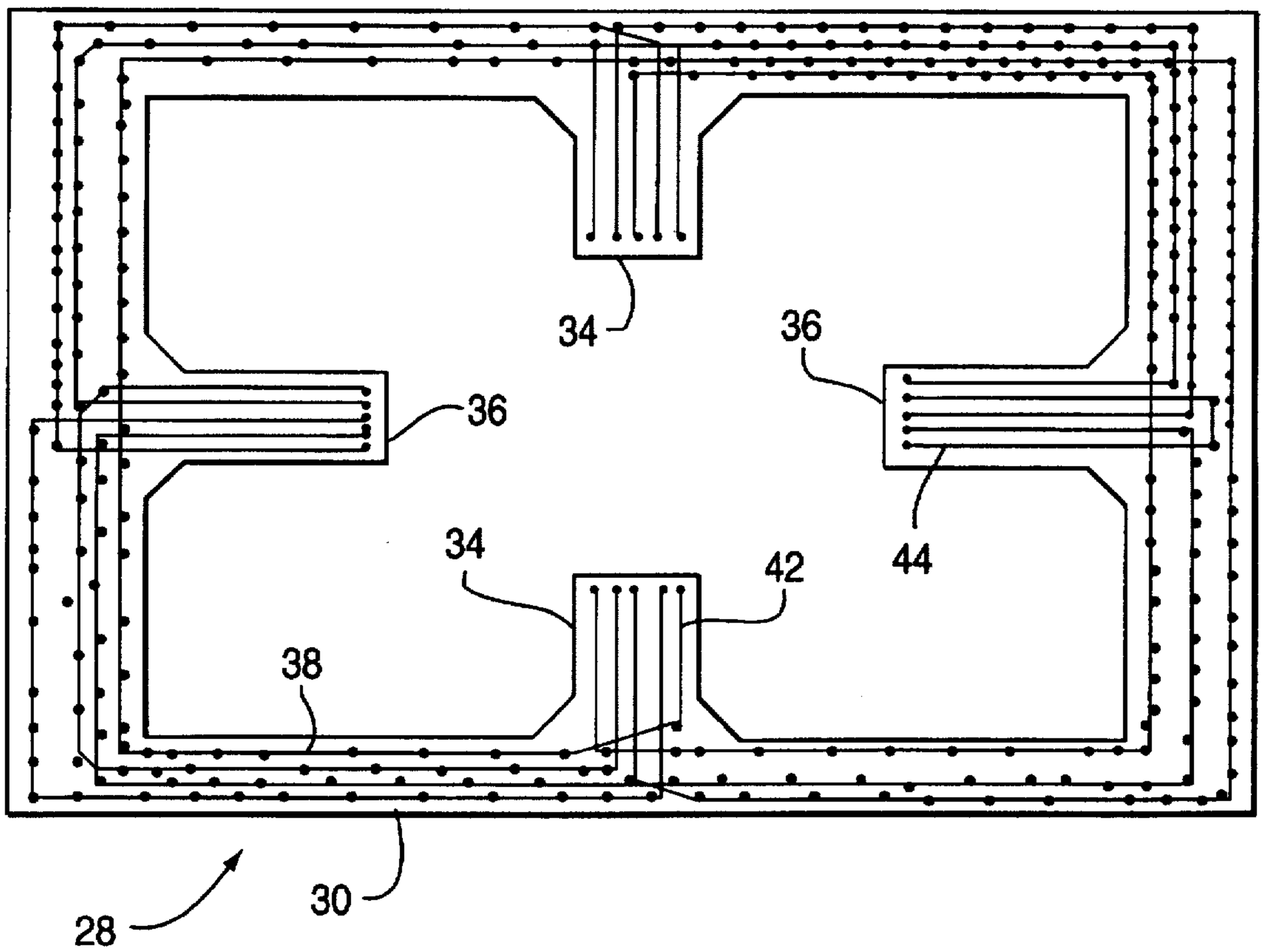


FIG. 3

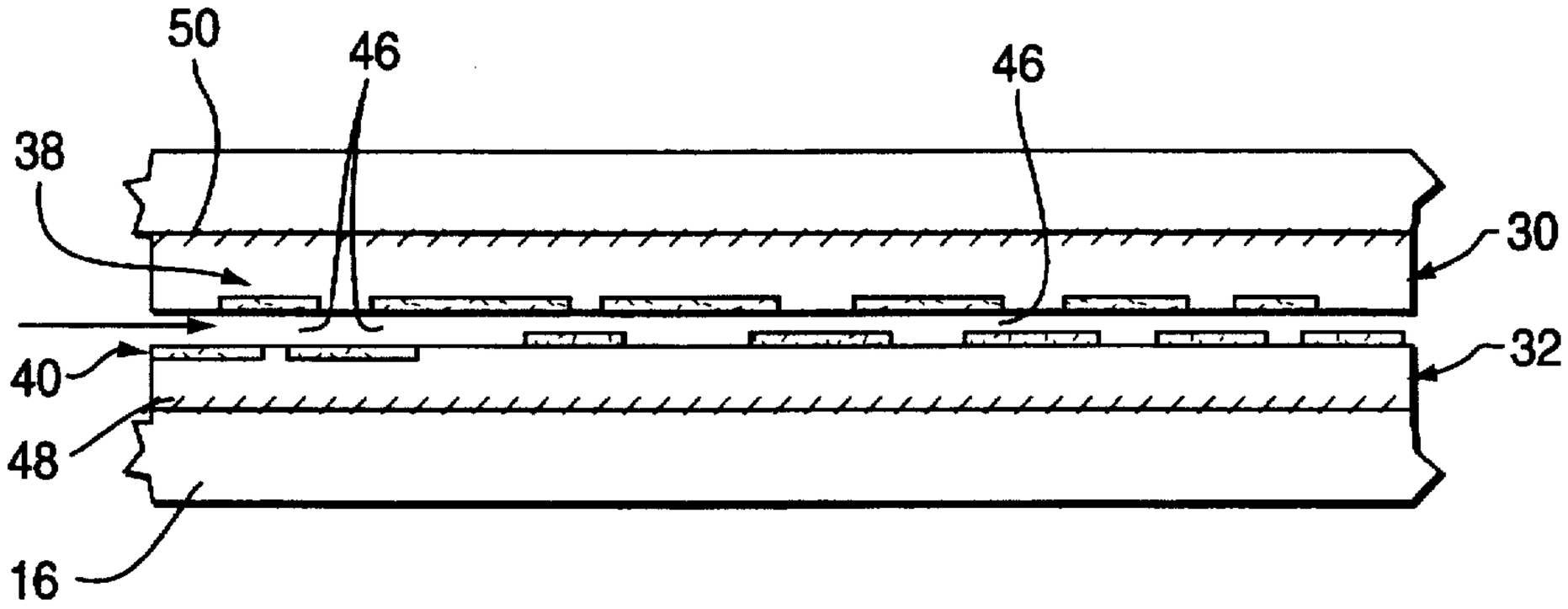


FIG. 4

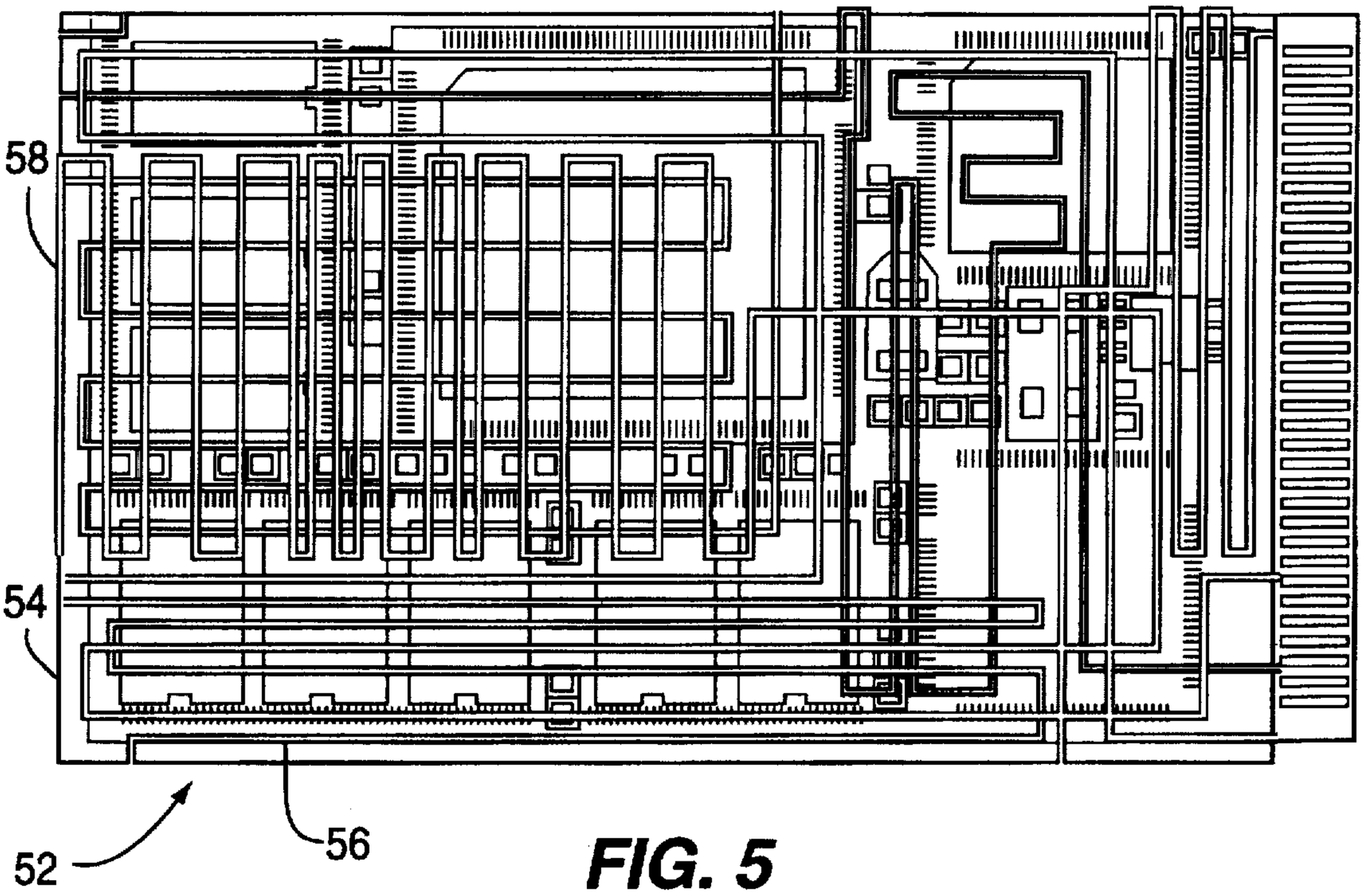


FIG. 5

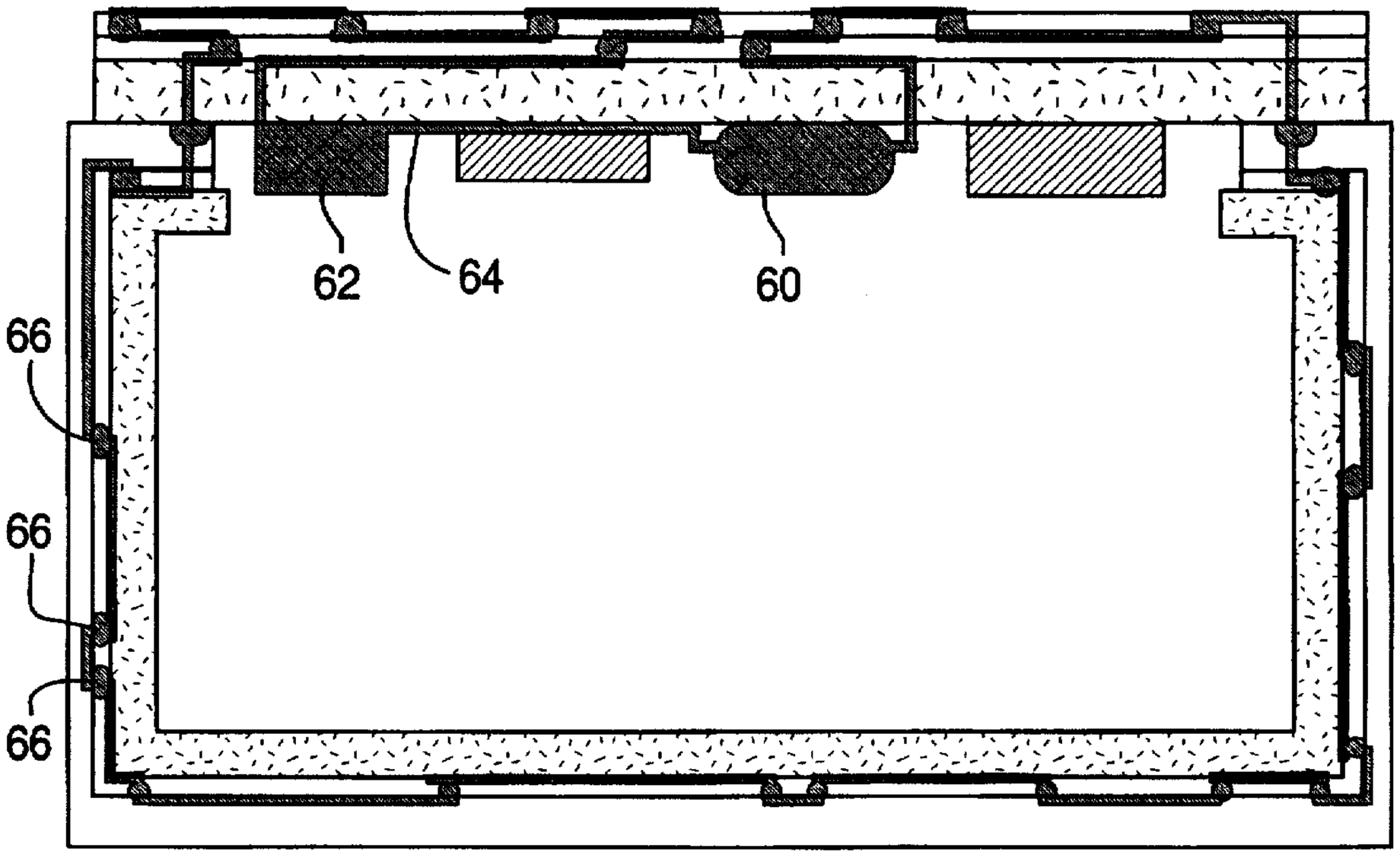


FIG. 6

TAMPER DETECTION DEVICE

STATEMENT OF GOVERNMENT INTEREST

This invention was made with Government support under MDA904-94-C-6054 awarded by Maryland Procurement Office. The Government has certain rights in this invention.

FIELD OF THE INVENTION

The invention relates to a tamper detection device for a housing, and, more particularly, to a tamper detection circuit which is placed between the parts of a housing to detect whether the housing has been tampered with.

BACKGROUND OF THE INVENTION

Electronic devices are generally enclosed in a housing of some type to protect the device from contaminants in the atmosphere, temperature, humidity and from being damaged during handling. The housing may have a cover extending over a printed circuit board on which the device is formed or comprise a multi-part housing surrounding the device. There are times when the housing may be tampered with, either accidentally or intentionally. If the housing is tampered with by either being penetrated or by being opened, the electronics in the housing may be damaged. Therefore, it would be desirable to provide a responsive housing with means to determine whether the housing has been tampered with. This would permit a variety of verification techniques to determine whether the electronics have been accessed because of the tampering with the housing.

SUMMARY OF THE INVENTION

A housing for a device includes at least a cover extending over the device. Under the cover is an electrical device whose electrical characteristics are changed if the cover is tampered with either by being penetrated or by being removed. The electrical device may be a capacitor extending across the cover, the capacitance of which will vary if penetrated, and/or may be an electrical circuit whose characteristics are changed if the cover is removed.

BRIEF DESCRIPTION OF THE DRAWING

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1** is a perspective view of a housing for an electrical device with which the tamper detection device of the invention may be used;

FIG. **2** is a perspective view of a capacitor which can be used in the housing of FIG. **1** to determine whether the cover of the housing is penetrated;

FIG. **3** is a top view of a flexible circuit which can be used in the housing of FIG. **1** to determine whether the cover of the housing has been removed;

FIG. **4** is a sectional view of the flexible circuit of FIG. **3** mounted in a housing;

FIG. **5** is a top view of another form of a flexible circuit which can be used to determine whether the cover of the housing has been penetrated; and

FIG. **6** is a top view showing the manner of connecting the flexible circuit of FIG. **5** to a detector means.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

Referring initially to FIG. **1**, a housing with which the tamper detection device of the invention can be used is generally designated as **10**. Housing **10** has a bottom portion **12** which comprises a bottom wall, not shown, upright side walls **14** extending from the bottom wall and a ledge **16** extending outwardly from the top edge of the side walls. The bottom portion **12** is adapted to contain the device to be protected by the housing **10**. The housing **10** also includes a cover **18**, preferably substantially flat, which is of a size and shaped to extend over the open side of the bottom portion **12** and rest on the ledge **16**. The cover **18** may be secured to the ledge **16** of the bottom portion **12** by any suitable means so as to completely enclose the device to be protected within the housing **10**.

Referring to FIG. **2** there is shown one form of a tamper detection device of the invention which is in the form of a capacitor **20**. Capacitor **20** comprises a plate **22** of an electrically conductive material which serves as one electrode of the capacitor **20**. A layer **24** of a dielectric material covers at least one side of the electrode plate **22**. A layer **26** of an electrically conductive material is over the dielectric layer **24** and serves as the other electrode of the capacitor **20**.

The materials of the capacitor **20** are such that if the capacitor **20** is penetrated, the electrical characteristics of the capacitor **20** will change. For example, the electrode plate **22** is preferably made of a metal which can be readily oxidized, such as aluminum. The dielectric layer **24** is preferably of aluminum oxide which is formed by anodizing the plate **22**. The conductive layer **26** is preferably of MnO_2 dispersed in a polyimide precursor binder. The conductive layer **26** may be applied to the dielectric layer **24** by brushing, spraying or other suitable coating technique. The MnO_2 acts as a conductor for normal operation of the capacitor **20**.

The capacitor **20** is placed across the inner surface of the cover **18** of the housing **10** and over the open side of the bottom portion **12**. The capacitor **20** may also be placed across the inner surfaces of the side walls **14**. The plates **22** and **26** of the capacitor **20** are connected across a source of current and to some type of detection and alarm system. If the cover **18** or side walls **14** of the housing **10** are penetrated, the capacitor **20** will also be penetrated. The penetration of the plates **22** and **26** and/or the dielectric layer **24** of the capacitor **20** will cause the capacitance of the capacitor **20** to change. This change in the capacitance of the capacitor **20** will be detected by the detection and alarm system which will provide an indication that the housing **10** has been tampered with by being penetrated.

Referring to FIGS. **3** and **4**, a flexible circuit in accordance with the invention is generally designated as **28**. Flexible circuit **28** comprises two sheets **30** and **32** of a flexible insulating material, such as a plastic. Each sheet **30** and **32** is of a shape and size corresponding to the ledge **16** of the bottom portion **12** of the housing **10**. As shown, the sheets **30** and **32** are rectangular with a separate arm **34** and **36** respectively extending inwardly from each side thereof. On one surface of each of the sheets **30** and **32** is a pattern of conductive strips **38** and **40** respectively. The conductive strips **38** and **40** can be in any desired pattern which extend completely around the sheets **30** and **32**. As shown, the conductive strips **38** and **40** are in the pattern of four separate lines extending around the sheets **30** and **32**. Conductive connecting strips **42** and **44** extend along the arms **34** and **36**. Each of the lines of the conductive strips **38** and **40** is connected to a line of each of the lines of the connecting strips **42** and **44** to form circuits around the sheets **30** and **32**.

The lines of the connecting strips **42** and **44** may be connected together to form either a single circuit or a plurality of separate circuits around the sheets **30** and **32**. The conductive strips **38**, **40**, **42** and **44** may be formed either by coating a conductive material on the surfaces of the sheets **30** and **32** in the desired pattern, such as by brushing or silk screening, or by bonding a layer of a conductive material to each of the sheets **30** and **32** and defining the conductive strips by etching the layer of conductive material.

As shown in FIG. **4**, the two sheets **30** and **32** are positioned with the patterns of conductive strips **38**, **40**, **42** and **44** facing each other but in slightly spaced relation. Between the conductive strips **38** and **42** on the sheet **30** and the conductive strips **40** and **44** on the sheet **32** are a plurality of conductive interconnects **46**. The interconnects **46** are positioned along the conductive strips **38**, **40**, **42** and **44** at a plurality of spaced points as shown by the dots in FIG. **3**. Each of the interconnects **46** is a bump of an adhesive material containing particles of a conductive material so as to be conductive. The adhesive material may be a polymer and the conductive particles may be of silver, carbon, copper or nickel. The interconnect bumps **46** may be applied to the conductive strips on one of the sheets **30** and **32** by silk screening. Each interconnect bump **46** is of sufficient thickness to space the two sheets **30** and **32** from each other. Once the interconnect bumps **46** are applied to strips on one of the sheets, the other sheet is positioned over the one sheet with its strips contacting the bumps **46**. The polymer in the interconnect bumps **46** is then cured to secure the two sheets **30** and **32** together in slightly spaced relation.

After the two sheets **30** and **32** are bonded together through the interconnect bumps **46**, the flexible circuit **28** is placed on the ledge **16** of the bottom portion **12** of the housing **10** as shown in FIG. **4**, with one of the sheets, such as the sheet **32**, being seated on the ledge **16**. A layer **48** of a strong adhesive is provided between the sheet **32** and the ledge **16** to secure the flexible circuit **28** to the ledge **16**. After the device is placed in the bottom portion **12** of the housing **10**, the cover **18** is placed over the ledge **16** and seated on the sheet **30** of the flexible circuit **28**. A layer **50** of a strong adhesive is provided between the cover **18** and the sheet **30** to secure the cover to the flexible circuit **28** and to the bottom portion **12** of the housing **10**.

In the device, the conductive strips **38** and **40** are electrically connected together in a circuit or a plurality of circuits through the interconnect bumps **46** and the connecting strips **42** and **44**. The circuit or circuits formed by the conductive strips **38** and **40** are connected to a detector and alarm system either in the housing **10** or external of the housing **10**. Thus, if the circuit or circuits are broken, it will be detected by the detector which will operate the alarm. If the cover **18** is removed from the housing **10**, the interconnect bumps **46** will be broken to break the circuit or circuits and provide a suitable alarm. The interconnect bumps **46** are so positioned along the conductive strips **38** and **40** that if someone attempted to insert an instrument, such as a screw driver, between the ledge **16** on the bottom portion **12** of the housing **10** and the cover **18**, at least one of the interconnect bumps **46** will be broken to break a circuit and provide an alarm. Thus, the flexible circuit **28** provides for detecting any attempt to tamper with the housing **10** and provide a suitable alarm.

Referring now to FIG. **5**, another form of the flexible circuit of the invention which can be used to determine whether a cover has been penetrated is generally designated as **52**. Flexible circuit **52** comprises a sheet **54** of a flexible insulating material, such as a plastic, of a shape and size corresponding to the open side of a housing. The sheet **54** is larger than the open side of the housing so that a portion of the edges of the sheet **54** can be folded down along the sides of the housing. On the sheet **54** are a plurality of strips **56** and **58** of a conductive material, such as a metal. The conductive strips **56** and **58** may be formed on opposite sides of the sheet **54** or on one side with a layer of an insulating material therebetween. Although the flexible circuit **52** is shown as having two conductive strips **56** and **58** thereon, it may have any desired number of the strips. Each of the strips **56** and **58** is arranged in a meandering path across the surface of the sheet **54** and cross each other in a number of places so that the strips cover a substantial portion of the surface of the sheet **54**.

In the use of the flexible circuit **52**, the sheet **54** is placed over the open side of a housing with the cover of the housing being placed over the sheet **54**. The edges of the sheet **54** are folded along the sides of the housing. As shown in FIG. **6**, the housing **10** may contain a circuit which includes a battery **60**, an alarm **62** and a circuit pattern **64** electrically connecting the alarm **62** and the battery **60**. The portions of the strips **56** and **58** on the edge portions of the sheet **54** are electrically connected to the circuit pattern **64** by conductive interconnections **66** so that the strips **56** and **58** are electrically connected in the circuit containing the battery **60** and the alarm **62**. Thus, if someone attempts to penetrate the cover, at least one of the strips **56** and **58** will be broken so as to break the circuit in which the strips **56** and **58** are connected. This will cause the alarm **62** to indicate that the circuit is broken and an attempt to penetrate the housing has occurred.

Thus, there is provided by the invention a device for mounting on a housing to provide means to indicate whether the housing has been tampered with either by having the cover of the housing penetrated or removed. The tamper detection means includes an electrical device whose electrical characteristics change if it is tampered with. The device can be a capacitor whose capacitance changes if penetrated, or a flexible circuit having a plurality of conductive strips thereon which will provide an open circuit if the housing is tampered with. It is to be understood that the apparatus and method of operation taught herein are illustrative of the invention. Modifications may readily be devised by those skilled in the art without departing from the spirit or scope of the invention.

We claim:

1. A housing for a device comprising:

a bottom portion for containing the device and having an open side;

a cover extending over the open side of the bottom portion and secured to the bottom portion; and

a capacitor extending across the open side of the bottom portion and under the cover, said capacitor having electrical characteristics which change if the cover is tampered with by being penetrated and/or removed.

2. The housing of claim **1** in which the capacitor comprises a flexible metal sheet having a dielectric coating over one surface and a conductive layer over the dielectric layer.

3. The housing of claim 2 in which the dielectric coating is an oxide of the metal sheet, and the conductive layer is particles of a conductive material in a plastic binder.

4. A housing for a device comprising:

a bottom portion for containing the device and having an open side;

a cover extending over the open side of the bottom portion and secured to the bottom portion; and

electrical means between the cover and the bottom portion and secured to the bottom portion having electrical characteristics which change if the cover is tampered with by being penetrated and/or removed, wherein the electrical means comprises:

two sheets of a flexible plastic with each sheet having thereon a pattern of conductive strips, said sheets overlapping each other with the conductive strips facing each other but slightly spaced apart, and conductive interconnects extending between various points on the conductive strips on the sheets to electrically connect the conductive strips on the two sheets.

5. The housing of claim 4 in which the interconnects are bumps of a conductive material in a bonding material so that the bumps secure the sheets together in spaced relation and electrically connect the conductive strips on the two sheets.

6. The housing of claim 5 in which the flexible circuit extends between mating portions of the bottom portion and the cover with one sheet being bonded to the bottom portion and the other sheet being bonded to the cover.

7. The housing of claim 6 in which the sheets are bonded to their respective bottom portion and cover by a bonding means which is stronger than the bonding material of the bumps.

8. A housing for a device comprising:

a bottom portion for containing the device and having side walls and an open side;

a cover extending over the open side of the bottom portion and secured to the side walls of the bottom portion;

a flexible circuit having a pattern of conductive strips on a flexible sheet of plastic, said flexible circuit extending across the open side of the bottom portion, under the cover and across the side walls of the bottom portion, the conductive strips extending in a pattern which covers a large portion of the flexible sheet so that the electrical characteristics of the flexible circuit will change if the cover is tampered with by being penetrated and/or removed.

9. The housing of claim 8 in which the conductive strips are on both sides of the flexible sheet.

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